Development of Pressure Swing Adsorption Technology for Spaceflight Medical Oxygen Concentrators

Completed Technology Project (2009 - 2013)

Project Introduction

There were 8 tasks associated with this project. These tasks are listed below. All were completed on schedule. In the year 1, Tasks 1, 2, and 6 were initiated. In the year 2, in addition, Tasks 3 and 4 were initiated, and Task 5 was initiated ahead of schedule. In year 3, Tasks 1-6 were all underway. In year 4, Tasks 1 to 8 were either completed, or underway and completed at the end of the period. More detail about each task is provided below. Task 1. Refine Model Parameters: Vanderbilt worked with USC to continually update the dynamic cyclic adsorption process simulator (DAPS) with the most up to date thermodynamic and kinetic parameters. Task 2. Validate DAPS: USC worked with Chart to obtain system dimensions, operating conditions, and extensive experimental performance data of Chart's Eclipse system and then used it to calibrate and validate DAPS. Significant progress was made with respect to DAPS quantitatively predicting the performance of the Eclipse system. Task 3. Optimize and Understand the Chart PSA Cycle: Using the refined and validated DAPS, USC, with input from Chart, carried out extensive parametric studies of Chart's PSA cycle to determine if it was possible to improve oxygen recovery, productivity, or both while maintaining the oxygen purity and without redesigning the PSA module. There were some key findings with DAPS that were recently verified experimentally by Chart. Task 4. Examine Alternative PSA Cycles: Using the refined DAPS, USC, with input from Chart, explored new PSA cycle designs and cycle schedules to determine if it might be possible to improve the oxygen recovery, productivity, or both while maintaining the oxygen purity by redesigning the PSA module. Task 5. Redesign and Build Improved PSA Module: Based on DAPS predictions, Chart designed a new PSA module that successfully delivered 4 lpm (litres per minute) of product in about an 8 lb assembly with a compressor shaft power of 130 Watts. Task 6. Define Compressor Specifications and Build Feasibility Prototype for 4 LPM System: Chart developed a compressor suitable for a 3 LPM oxygen PSA system through a different funding source. Specifications and requirements were identified and a feasibility prototype was built built during this project to provide sufficient pressure and vacuum to supply a 4 LPM system. Task 7. Assemble and Test Breadboard Systems: Chart assembled two breadboard demonstration systems that incorporated the new PSA module with the redesigned compressor. These breadboard systems are currently being tested by the MSFC and Glenn Research Center to determine new weight and performance targets and for down selection for flight development. Task 8. Verify DAPS Predictions of New PSA Modules: Using the refined cyclic adsorption process simulator, USC carried out studies of redesigned systems and new prototypes to verify the simulation results, to determine optimum operating conditions, and to understand the performance limits of the new systems.

Anticipated Benefits

A major expectation of the research is the development of smaller medical

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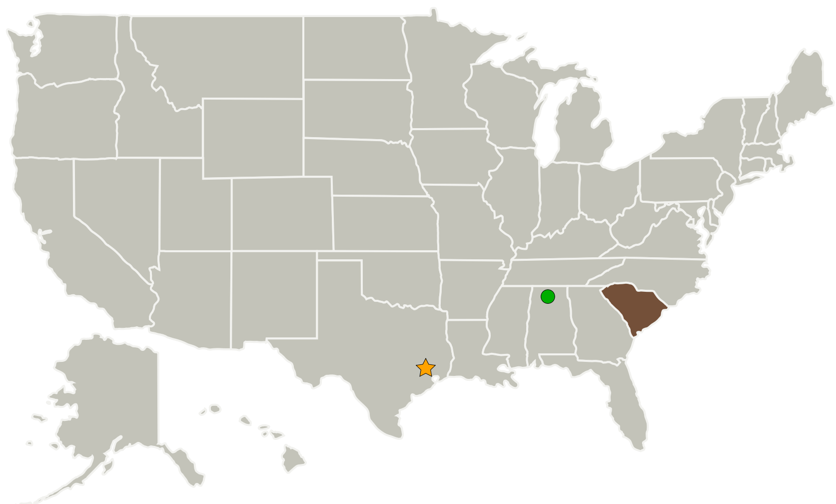
oxygen concentrators, which will be of benefit not only for spaceflight but also for medical patients on Earth in need of oxygen enriched air.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
●Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama
SeQual Technologies	Supporting Organization	Industry	
University of South Carolina-Columbia	Supporting Organization	Academia	Columbia, South Carolina
Vanderbilt University	Supporting Organization	Academia	Nashville, Tennessee

Organizational Responsibility

Responsible Mission Directorate:

Space Operations Mission Directorate (SOMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Human Spaceflight Capabilities

Project Management

Program Director:

David K Baumann

Principal Investigator:

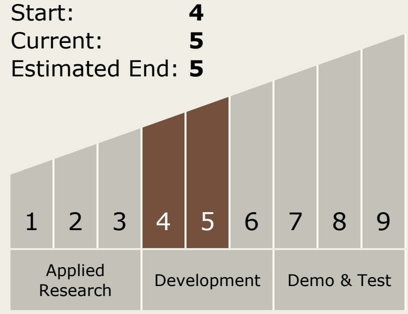
James A Ritter

Co-Investigators:

Douglas Levan
James C Knox
Paul R Edwards

Technology Maturity (TRL)

Start: **4**
Current: **5**
Estimated End: **5**



Development of Pressure Swing Adsorption Technology for Spaceflight Medical Oxygen Concentrators

Completed Technology Project (2009 - 2013)

Primary U.S. Work Locations

South Carolina

Project Transitions

September 2009: Project Start

August 2013: Closed out

Closeout Summary: There were 8 tasks associated with this project. These tas ks are listed below. All were completed on schedule. In the year 1, Tasks 1, 2, a nd 6 were initiated. In the year 2, in addition, Tasks 3 and 4 were initiated, and Task 5 was initiated ahead of schedule. In year 3, Tasks 1-6 were all underway. In year 4, Tasks 1 to 8 were either completed, or underway and completed at th e end of the period. More detail about each task is provided below. Task 1. Refin e Model Parameters: Vanderbilt worked with USC to continually update the dyna mic cyclic adsorption process simulator (DAPS) with the most up to date thermo dynamic and kinetic parameters. Task 2. Validate DAPS: USC worked with Chart to obtain system dimensions, operating conditions, and extensive experimental performance data of Chart's Eclipse system and then used it to calibrate and vali date DAPS. Significant progress was made with respect to DAPS quantitatively p redicting the performance of the Eclipse system. Task 3. Optimize and Understa nd the Chart PSA Cycle: Using the refined and validated DAPS, USC, with input f rom Chart, carried out extensive parametric studies of Chart's PSA cycle to dete rmine if it was possible to improve oxygen recovery, productivity, or both while maintaining the oxygen purity and without redesigning the PSA module. There w ere some key findings with DAPS that were recently verified experimentally by C hart. Task 4. Examine Alternative PSA Cycles: Using the refined DAPS, USC, wit h input from Chart, explored new PSA cycle designs and cycle schedules to deter mine if it might be possible to improve the oxygen recovery, productivity, or bot h while maintaining the oxygen purity by redesigning the PSA module. Task 5. R edesign and Build Improved PSA Module: Based on DAPS predictions, Chart desi gned a new PSA module that successfully delivered 4 lpm (litres per minute) of product in about an 8 lb assembly with a compressor shaft power of 130 Watts. Task 6. Define Compressor Specifications and Build Feasibility Prototype for 4 LP M System: Chart developed a compressor suitable for a 3 LPM oxygen PSA syste m through a different funding source. Specifications and requirements were iden tified and a feasibility prototype was built built during this project to provide suff icient pressure and vacuum to supply a 4 LPM system. Task 7. Assemble and Te st Breadboard Systems: Chart assembled two breadboard demonstration system s that incorporated the new PSA module with the redesigned compressor. These breadboard systems are currently being tested by the MSFC and Glenn Research Center to determine new weight and performance targets and for down selection for flight development. Task 8. Verify DAPS Predictions of New PSA Modules: Usi ng the refined cyclic adsorption process simulator, USC carried out studies of re designed systems and new prototypes to verify the simulation results, to determ ine optimum operating conditions, and to understand the performance limits of t he new systems.

Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  - └ TX11.2 Modeling
    - └ TX11.2.3 Human-System Performance Modeling

Target Destinations

The Moon, Mars

Stories

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25105)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/34974)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/34973)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25431)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25851)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/8657)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/8658)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/34967)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/24941)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25032)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25470)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25546)

Awards
(https://techport.nasa.gov/file/25089)

Awards
(https://techport.nasa.gov/file/25898)

Awards
(https://techport.nasa.gov/file/8654)

Awards
(https://techport.nasa.gov/file/8655)

Awards
(https://techport.nasa.gov/file/8656)

NASA Technical Documents
(https://techport.nasa.gov/file/34965)

Project Website:

https://taskbook.nasaprs.com